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ART UNIT	PAPER NUMBER
2126	

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Please find below and/or attached an Office communication concerning this application or proceeding.

	Application No.	Applicant(s)
Office Action Summary	09/837,671	DETLEFS ET AL.
	Examiner	Art Unit
	Lewis A. Bullock, Jr.	2126

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) FROM
THE MAILING DATE OF THIS COMMUNICATION.
- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed
  after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
  Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any
  earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☐ Responsive to communication(s) filed on _____ .

2a)☐ This action is **FINAL**.   2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is
closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-35* is/are pending in the application.

    4a) Of the above claim(s) *22-28* is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-3,7-10,13-21 and 29-35* is/are rejected.

7)☒ Claim(s) *4-6,11 and 12* is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *18 April 2001* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

    Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

    Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

    a)☐ All   b)☐ Some * c)☐ None of:

      1.☐ Certified copies of the priority documents have been received.

      2.☐ Certified copies of the priority documents have been received in Application No. _____ .

      3.☐ Copies of the certified copies of the priority documents have been received in this National Stage
application from the International Bureau (PCT Rule 17.2(a)).

    * See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1)☒ Notice of References Cited (PTO-892)

2)☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)

3)☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)
Paper No(s)/Mail Date *5*.

4)☐ Interview Summary (PTO-413)
Paper No(s)/Mail Date. _____ .

5)☐ Notice of Informal Patent Application (PTO-152)

6)☐ Other: _____ .

DETAILED ACTION

Election/Restrictions

1.   Restriction to one of the following inventions is required under 35 U.S.C. 121:

I.   Claims 1-21 and 29-35 are, drawn to providing storage reclamation for shared objects, classified in class 719, subclass 315.

II.   Claims 22-28 are, drawn to transforming a concurrent shared data structure from garbage collection dependent to garbage collection independent, classified in class 707, subclass 206.

The inventions are distinct, each from the other because of the following reasons:

2.   Inventions Group I and Group II are related as subcombinations disclosed as usable together in a single combination. The subcombinations are distinct from each other if they are shown to be separately usable. In the instant case, invention Group II has separate utility such as modifying the implementation, if necessary, to ensure cycle-free garbage and replacing pointer accesses in the implementation with corresponding lock-free reference-count-maintaining counterpart operations. See MPEP § 806.05(d).

3.   Inventions Group I and Group II are related as process of making and product made. The inventions are distinct if either or both of the following can be shown: (1) that the process as claimed can be used to make other and materially different product or (2) that the product as claimed can be made by another and materially different process (MPEP § 806.05(f)). In the instant case the product as disclosed in Group I does not have to be made as disclosed in the process disclosed in Group II. One of ordinary skill in the art can create an independent shared data structure having a

reference count and corresponding access methods without converting this structure from a previous system, i.e. one that was garbage collection dependent.

4.   Because these inventions are distinct for the reasons given above and have acquired a separate status in the art as shown by their different classification, different search, and recognized divergent subject matter, restriction for examination purposes as indicated is proper.

5.   During a telephone conversation with David O'Brien on April 16, 2004 a provisional election was made with traverse to prosecute the invention of Group I, claims 1-21 and 29-35. Affirmation of this election must be made by applicant in replying to this Office action. Claims 22-28 are withdrawn from further consideration by the examiner, 37 CFR 1.142(b), as being drawn to a non-elected invention.

6.   Applicant is reminded that upon the cancellation of claims to a non-elected invention, the inventorship must be amended in compliance with 37 CFR 1.48(b) if one or more of the currently named inventors is no longer an inventor of at least one claim remaining in the application. Any amendment of inventorship must be accompanied by a request under 37 CFR 1.48(b) and by the fee required under 37 CFR 1.17(i).

Claim Rejections - 35 USC § 102

7.   The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

8.   Claims 1, 2, 7-9, 13-17, 20, 29, 30 and 33-35 are rejected under 35

U.S.C. 102(b) as being anticipated by "Managing Long Linked Lists Using Lock-Free

Techniques" by FAROOK.

As to claim 1, FAROOK teaches a method of providing storage reclamation in a

multiprocessor computer system (a parallel environment in which each process

executes alone on a processor) (pg. 15, Performance of the New Algorithm), the

method comprising: maintaining respective reference counts (counter fields) for shared

objects (list nodes) (pg. 9, "Each node in the linked list consists of four fields; a data

field, two pointer fields, and a count field...the counter field in each list node is used...");

accessing pointers to the shared objects (list nodes) using lock-free pointer operations

(cursor / TryDelete of delete / TryInsert of insert) to coordinate modification of respective

reference counts (see figs. 6-9; pg. 9, section 4.2 Linked List Traversal – pg. 13,

"Otherwise, the 'prev' node's counter field is decremented (line 14) and the appropriate

result status is returned."); free storage associated with a particular one of the shared

objects (list nodes) only once the corresponding reference count (counter fields)

indicates that the particular shared object is unreferenced (pg. 12, "The code then

decrements the counter of node 'prev' (as it is no longer being used) and, if possible

releases the deleted node (line 3) to reclaim space."; pg. 9, "A process attempting a

node deletion must first verify that its counter field is zero before proceeding.").

As to claim 2, FAROOK teaches the lock-free pointer operations (cursor /

TryDelete of delete / TryInsert of insert) ensure that: if a number of pointers referencing

the particular shared object (list nodes) is non-zero, then so too is the corresponding

reference count (via as the user moves from node to node it increments the counter

field of the node its visiting and decrements it when it is leaving) (pg. 9, 2nd paragraph);

and if no pointers reference the particular shared object (list nodes), then the

corresponding reference count eventually becomes zero (via the reference count is not

increment since no node is visiting it) (pg. 9, 2nd paragraph).

As to claim 7, FAROOK teaches the pointer operations include a destroy

operation (delete operation) that: decrements a reference count (counter field) of a

shared object (list node) identified by a supplied pointer value (key); and frees the

identified shared object if the corresponding reference count has reached zero (via

release instruction) (see fig. 6 and 7, pgs.11-12).

As to claim 8, FAROOK teaches wherein, prior to the freeing (via release

instruction), the destroy operation (delete operation) recursively follows pointers defined

in the shared object (list node) if the corresponding reference count (counter field) has

reached zero (via TRY_AGAIN / DELETE_AGAIN instructions) (see fig. 6 and 7,

pgs.11-12).

As to claim 9, FAROOK teaches employed in access operations (cursor /

TryDelete of delete / TryInsert of insert) on a composite shared object (linked list) that

includes zero or more of the shared objects (list nodes) (pg. 8-13).

As to claim 13, FAROOK teaches a lock-free implementation of a concurrent

shared object (linked list) comprising: plural component shared objects (list nodes)

encoded in dynamically-allocated shared storage (shared memory machine) (abstract;

pg. 9, "Each node in the linked list consists of four fields; a data field, two pointer fields,

and a count field...the counter field in each list node is used..."); and access operations

(cursor / TryDelete of delete / TryInsert of insert) that, prior to attempting creation or

replication of a pointer (accessing a particular node) to any of the component shared

objects (list node), increment a corresponding reference count (counter field), and upon

failure of the attempt (process has failed due based on DCAS or CAS operation) (pg.

14-15), thereafter decrement the corresponding reference count (counter field), the

access operations (cursor / delete / insert) decrementing a particular reference count

(counter field), except when handling a pointer creation failure, no earlier than upon

destruction of a pointer to a corresponding one of the component shared objects (list

nodes) (see figs. 6-9; pg. 9, section 4.2 Linked List Traversal – pg. 13, "Otherwise, the

'prev' node's counter field is decremented (line 14) and the appropriate result status is

returned."; pg. 12, "The code then decrements the counter of node 'prev' (as it is no

longer being used) and, if possible releases the deleted node (line 3) to reclaim space.";

pg. 9, "A process attempting a node deletion must first verify that its counter field is zero

before proceeding."; see also pg. 14-15).

As to claim 14, FAROOK teaches the access operations employ lock-free, reference-count-maintaining pointer operations (via the delete and insert operations use of CAS or DCAS) (See Fig. 6-9, pgs. 11-13).

As to claim 15, FAROOK teaches a lock-free, reference count maintaining destroy operation (delete operation) (pg. 11-12).

As to claim 16, FAROOK teaches each of the access operations (insert / delete) are lock-free (non-blocking) (abstract; pg. 9; pg. 17, Conclusions & Future Work).

As to claim 17, FAROOK teaches the access operations (insert / delete) employ either a compare-and-swap primitive or a double compare-and-swap primitive (via the delete and insert operations use of CAS or DCAS) (See Fig. 6-9, pgs. 11-13).

As to claim 20, FAROOK teaches wherein the incrementing and decrementing are performed using a synchronization primitive (in the delete operation wherein r represents the DCAS operation and if it is true the counter is decremented) (See Fig. 6-9, pgs. 11-13).

As to claim 29, FAROOK teaches a computer program product (computer instructions) encoded in at least one computer readable medium comprising (shared memory machine) (abstract; pg. 9, "Each node in the linked list consists of four fields; a

data field, two pointer fields, and a count field...the counter field in each list node is used..."): a representation of a shared object (linked-list) that is instantiable as zero or more component objects (list nodes) in dynamically allocated shared storage (shared memory machine) of a multiprocessor (a parallel environment in which each process executes alone on a processor) (pg. 15, Performance of the New Algorithm); at least one instruction sequence executable by respective processors of the multiprocessor, the at least one instruction sequence implementing at least one access operation (cursor / insert / delete) on the shared object (linked-list) and employing one or more lock-free pointer operations (increment / decrement counter in access operations) to maintain reference counts (counter fields) for one or more accessed component objects (list nodes) thereof (see figs. 6-9; pg. 9, section 4.2 Linked List Traversal – pg. 13, "Otherwise, the 'prev' node's counter field is decremented (line 14) and the appropriate result status is returned."; pg. 12, "The code then decrements the counter of node 'prev' (as it is no longer being used) and, if possible releases the deleted node (line 3) to reclaim space."; pg. 9, "A process attempting a node deletion must first verify that its counter field is zero before proceeding."; see also pg. 14-15); and the at least one instruction sequence further implementing explicit reclamation of the component objects (list nodes), thereby freeing storage associated with a particular one of the component objects (list nodes) only once the corresponding reference count (counter fields) indicates that the particular component object is unreferenced (via the instruction that if target counter or prev counter is equal to 0 then to release that node) (see fig. 7, pg. 12).

As to claim 30, FAROOK teaches the zero or more component objects (list nodes) of the shared object (linked list) are organized as a linked-list; and wherein the at least one access operation (cursor / insert / delete) supports concurrent access to the linked-list (non-blocking concurrent access) (pg. 9; abstract; pg. 14-15, "We begin by noting that non-adjacent updates do not affect one another since, synchronization is localized (i.e. fine granularity concurrency control).").

As to claim 33, FAROOK teaches the computer readable medium is electronic storage medium (shared memory machine) (abstract).

As to claim 34, FAROOK teaches an apparatus (system) comprising: plural processors (a parallel environment in which each process executes alone on a processor) (pg. 15, Performance of the New Algorithm); a store addressable by the plural processors (shared memory storing the linked list); one or more shared pointer variables (head / tail pointers) accessible by each of the plural processors for referencing a shared object (linked list) encoded in the store; means for coordinating competing access to the shared object (linked list / list node) using one or more reference counts (counter fields) and pointer manipulations (via instructions manipulating the next or prev pointer values in the cursor function / delete function / insert function) that employ one or more lock-free pointer operations (cursor / delete / insert) to ensure that if the number of pointers to the shared object (linked list / list node)

is non-zero (node is being referenced / visited) particular , then so too is the

corresponding reference count (via each process increments the counter of a node it is

about to traverse) and further that if no pointers reference the shared object (process is

leaving node), then the corresponding reference count (counter field) eventually

becomes zero (via each process decrements the counter of a node it is leaving) (pgs 8-

13).

As to claim 35, FAROOK teaches means for freeing the shared object (list node)

only once the corresponding reference count (counter field) indicates that the shared

object is unreferenced (via the instruction that if target counter or prev counter is equal

to 0 then to release that node) (see fig. 7, pg. 12).

Claim Rejections - 35 USC § 103

9.   The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all

obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set
> forth in section 102 of this title, if the differences between the subject matter sought to be patented and
> the prior art are such that the subject matter as a whole would have been obvious at the time the
> invention was made to a person having ordinary skill in the art to which said subject matter pertains.
> Patentability shall not be negatived by the manner in which the invention was made.

10.   Claims 3 and 21 is rejected under 35 U.S.C. 103(a) as being unpatentable over

"Managing Long Linked Lists Using Lock-Free Techniques" by FAROOK.

As to claim 21, FAROOK teaches wherein the concurrent shared object is a

linked-list (pg. 8); and wherein the access operations (insert / delete) are performed

using a synchronization primitive (DCAS / CAS) to mediate concurrent execution thereof (pg. 8-15). However, FAROOK does not teach the linked list is a doubly linked list.

Official Notice is taken in that it is well known in the art at the time of the invention that a doubly linked list is a version of a linked list wherein each node has a pointer to the next and previous nodes. Therefore, it would be obvious to one skilled in the art that the linked list of FAROOK can be implemented as a doubly linked list and allow concurrent execution to itself by the cited access operations.

As to claim 3, FAROOK teaches that as concurrent processes access a shared object, i.e. visit a shared node of the shared object, they increment that nodes reference count (abstract, pg. 8-15). It is obvious to one skilled in the art that since accesses to the shared object are concurrently that when both processes access the object at the same time neither would have the true reference count, i.e. if the reference count of a shared object is one and concurrent access is made by concurrently accessing processes each process would increment to two wherein the correct amount of pointers is three.

11. Claim 10 is rejected under 35 U.S.C. 103(a) as being unpatentable over "Managing Long Linked Lists Using Lock Free Techniques" by FAROOK in view of "Simple, Fast, and Practical Non-Blocking and Blocking Concurrent Queue Algorithms" by MICHAEL.

As to claim 10, FAROOK teaches the composite shared object is a linked list and the shared objects are nodes of the linked list and wherein the access operations implement push (insert) and pop (delete) accesses to opposing ends of the linked list (pg. 8-13). However, FAROOK does not teach the linked list is a doubled ended queue.

MICHAEL teaches a queue implemented as a linked list having a head and tail pointers wherein nodes are pushed (enqueue operation) after the last node in the linked list and pop (dequeue operation) from the beginning of the linked list (pg. 3-5, Sections Algorithms (2) and Correctness (3)). It would be obvious that based on the combination that FAROOK's linked list is a queue capable of being manipulated as disclosed in MICHAEL. Therefore, it would be obvious to one skilled in the art to combine the teachings of FAROOK with the teachings of MICHAEL in order to facilitate access operations of a non-blocking concurrent queue to proceed concurrently (abstract).

12.   Claims 18 and 19 are rejected under 35 U.S.C. 103(a) as being unpatentable over "Managing Long Linked Lists Using Lock-Free Techniques" by FAROOK in view of "Transactional Memory: Architectural Support for Lock-Free Data Structures" by HERLIHY.

As to claim 18, FAROOK substantially discloses the invention above. However, FAROOK does not mention the access operations employ emulations of the compare-and-swap operation.

HERLIHY teaches the access operations (enqueue / dequeue) employ

emulations of either or both of the compare-and-swap and double-compare-and-swap

operations (via transaction memory) (pg. 8, section 5.3, Doubly-Linked List Benchmark;

abstract). Therefore, it would be obvious to one skilled in the art to combine the

teachings of FAROOK with the teachings of HERLIHY in order to facilitate efficient lock-

free synchronization based on mutual exclusion (abstract).

As to claim 19,HERLIHY teaches wherein the emulation is based on

transactional memory (pg. 8, section 5.3, Doubly-Linked List Benchmark; abstract).

13.   Claims 31 and 32 are rejected under 35 U.S.C. 103(a) as being unpatentable

over "Managing Long Linked Lists Using Lock-Free Techniques" by FAROOK in view of

"Garbage Collection: Algorithms for Automatic Dynamic Memory Management" by

JONES.

As to claim 31, FAROOK teaches component objects (list nodes) having a

reference count (counter field) (pg. 8). However, FAROOK does not teach using a

mutator to provide explicit reclaimation.

JONES teaches partially implementing a mutator (mutator) that provides explicit

reclamation of the dynamically allocated shared storage (concurrent reference counter)

(via notifying the collector) (pg. 200-201). Therefore, it would be obvious to combine the

teachings of FAROOK with the teachings of JONES in order to efficiently manipulate

reference counters in a concurrent environment (pg. .200).

As to claim 32, JONES teaches partially implementing a garbage collector

(garbage collector) that reclaims shared storage dynamically-allocated from a mutator

(mutator) (pg. 200-201).

Allowable Subject Matter

14.   Claims 4-6, 11 and 12 are objected to as being dependent upon a rejected base

claim, but would be allowable if rewritten in independent form including all of the

limitations of the base claim and any intervening claims.

15.   The following is a statement of reasons for the indication of allowable subject

matter: The cited claims contain allowable subject matter for at least the following

reasoning: All of the claims detail a plurality of lock-free pointer operations, i.e a load

operation, a store operation, a copy operation, and a push access operation that are not

taught by any of the prior art of record. Each of the cited operations perform a plurality

of compare-and-swap and double-compare-and swap primitives that affect not only the

reference count but also the pre-load value of the local pointer value, the pre-store

value of the shared pointer variable, the pre-copy value of the local pointer value, or the

in pre-splice pointer values. By performing DCAS and CAS operations as disclosed in

the claims, the invention allows for the separation of the updates of reference counts

from the updates of the pointers themselves (pg. 7, par. 1021). All of the prior art of

record detail common practices of allowing the pointers to record the exact number of

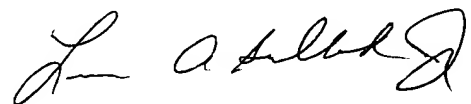pointers to an object. FAROOK teaches this common practice in that each insert or

delete operation manipulates the counter for the accessed node however this manipulation is not performed by the DCAS or CAS operations with the access operations. Therefore, the claims are allowable over the prior art of record.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Lewis A. Bullock, Jr. whose telephone number is (703) 305-0439. The examiner can normally be reached on Monday-Friday, 8:30 am - 5:00 pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Meng An can be reached on (703) 305-9678. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

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